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R&D and manufacturing production specialisation in developed economies

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ABSTRACT

A study of the relation between technology and manufacturing production specialisation in a series of developed economies is performed by means of models relating indicators of revealed symmetric comparative advantage of value added and exports to similar measures of comparative performance of R&D expenditure, capital intensity, total factor productivity and wage costs. The production and R&D specialisation are shown to be substantial and sticky. This contrasts with the evidence of a substantial degree of convergence in the patterns of the other variables. Regression estimates show that, although all variables play their part, the impact of comparative R&D efforts on production specialisation is by far the strongest. This impact is found to be stronger in the smaller economies and it is especially important in research intensive industries. The influence of comparative wages is, moreover, found to be positive here, suggesting the dominance of a labour skill and efficiency wage effect over a wage cost competitiveness effect. These findings are shown to conform quite well with the predictions of Schumpeterian theory and of certain contributions to 'new trade theory' that have stressed the importance of dynamic economies of scale.

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I. INTRODUCTION

There has recently been a growing awareness in economic policy circles of developed economies of the importance of the relation between technology and production specialisation. Policies aimed at influencing the pattern of production specialisation should, in this view, in the first place be innovation policies. A good example of this are the EU's technology initiatives within its framework programmes, aimed at promoting R&D driven regional clusters and product developments that are, supposedly, fundamental to Europe's sustainable development and industrial competitiveness (see, for example, CEC, 2005 a, 2005 b).

But what do we really know about the connection between technology and production specialisation? How strong is it? And how does the impact of technology compare with that of other explanatory variables? Although, as seen below, there is a growing theoretical literature on the issue of trade and technology, the related empirical work mainly concentrates on trade performance. Only a very limited number of studies have, thus far, attempted to investigate the relation between technology and production specialisation. Even though they have their own merits, they each time suffer from major weaknesses, so that it is still difficult to provide clear answers to these questions.

In this study we try to shed further light on this. We analyse the behaviour of a revealed comparative advantage indicator based on manufacturing value added, RCAV, as well as one based on the value of manufacturing exports, RCAE. We do so by considering the evolution of their standard deviation and by estimating autoregressive equations relating them at different points in time. We then attempt to identify the main determinants of value added and export specialisation, by means of a regression analysis relating the RCAV and RCAE to revealed comparative performance indicators of wage costs, physical capital intensity, total factor productivity (TFP) and R&D expenditure. We also investigate, thereby, the existence of systematic differences in behaviour between large and small economies, and between research intensive and less research intensive sectors.

The paper is organised as follows. Section II briefly reviews the relevant theoretical and empirical literature. Section III presents the measures of specialisation, the econometric models and the econometric methods. The empirical results are reported in Section IV. Section V summarises and concludes. The data sources and measurement issues are mentioned in a separate Appendix.

II. TRADE AND TECHNOLOGY: THEORY AND EMPIRICAL EVIDENCE

II.1. *Theory*

During the past two decades a substantial empirical literature has emerged on the issue of trade and technology. Most of this work is strongly influenced by Schumpeterian theory. According to this, technical progress is, in the first place, endogenous in nature, being the product of profit motivated innovation efforts by firms. The resulting process of technical change has a cumulative character, as firms are constrained in the possibilities of what they can do by their past behaviour. To the extent that the dissemination of knowledge through international technical diffusion is, at most, partial and gradual in nature, developed economies will thereby be able to build up technological advantages in specific activities. This will strongly influence their production specialisation and international trade pattern (Pavitt, 1989, Cantwell, 1989, Dosi *et al.,* 1990). Empirically speaking, this Schumpeterian theory predicts: 1) that the manufacturing trade performance of developed economies is more affected by their technologically determined product qualitative performance than by their international price or cost competitiveness; 2) that their technological specialisation is substantial and sticky; and 3) that their production specialisation is much more closely related to their technological specialisation than to other factors such as their capital and labour factor endowments, emphasised by traditional neo-classical Heckscher-Ohlin theory.

In order to allow for a role of technological factors in the explanation of trade performance and production specialisation within a traditional endowments framework, some other authors have simply adapted it, by including in the production function additional factor inputs, such as human and R&D knowledge capital. Countries well endowed with such factors would, thereby, have a comparative advantage in the production of labour skill and research intensive goods (see, especially, Leamer, 1984). Although this 'neo-endowments' approach has led to similar test specifications as found in Schumpeterian inspired empirical work, its theoretical justification if far less convincing. It seems difficult to reconcile the implied assumption of equal accessibility of technology across countries with the possibility of a strong impact on production specialisation of unequal human and R&D capital endowments. Moreover, the black box nature of the innovation process in this approach does not allow to make meaningful predictions with respect to the stickiness of technological and, thereby, of production specialisation.

More interesting in this respect, is a brand of the so-called ‘new trade theory’, which has stressed the importance of dynamic learning effects. According to this, countries may originally specialise in a sector by chance. By doing so, they will achieve economies of scale through learning-by-doing. To the extent that the international dissemination of knowledge is only gradual and partial in nature, this will provide them with a comparative advantage in terms of total factor productivity (TFP) performance, which will, in turn, reinforce the existing specialisation pattern (see Krugman, 1987, 1991). Also here the prediction is of sticky production specialisation, and this argumentation can, therefore, be viewed as complementary to the Schumpeterian one.

The latter is also the case of some other theoretical work in the ‘new trade’ literature. This has emphasised the importance of dynamic economies of scale due to the existence of fixed costs in the research process, and it has stressed the positive impact of variety on consumer utility, providing a strong incentive for product innovation (see, especially, Helpman, 1982, Grossman and Helpman, 1989). Interesting empirical predictions are here that the degree of production specialisation is likely to be especially strong in small economies and among research intensive industries, and that there will be intra-industry trade, due to product differentiation within industries.

II. 2. *Empirical evidence*

Most related empirical work has concentrated on the issue of the impact of technology on manufacturing trade performance. Most notable for our purpose, are a series of disaggregate sector-country cross-section or panel data regression analyses with respect to manufacturing in developed economies. Equations are estimated relating the rate of growth or the level of export shares, or of bilateral trade, to variables such as relative unit labour costs or wage costs, investment intensity and R&D intensity or patent shares. The results suggest that, on average, the impact of the technology variables is more important, but also cost competitiveness appears to matter. Moreover, there is quite some heterogeneity in behaviour between sectors (see, especially, Amable and Verspagen, 1995, Verspagen and Wakelin, 1997, Landesmann and Pfaffermayr, 1997, Wakelin, 1998, and for surveys of earlier work, Wakelin, 1995, and Fagerberg, 1996).

Some other empirical work has analysed the stability of the specialisation patterns through time. These studies depict these patterns by means of Balassa (1965) type of Revealed Comparative Advantage (RCA) indexes. Cross-sectional sector- or country-wise regression estimates are then presented of equations relating these RCA indexes (or transforms of them) at different points in time, and the evolution of the corresponding standard deviations of the RCA variables is analysed. The most influential study of technological specialisation is due to Cantwell (1989) and it bases its measure of RCA on patent counts. The studies on production specialisation concentrate, by and large, exclusively on exports. The most comprehensive of these is due to Dalum *et al.* (1998) (a survey of earlier work is also given here). Their results suggest that the technological and export specialisation patterns of developed countries have been relatively sticky during the considered medium-run periods (of 2 to 3 decades) after WW II.

Only a very limited number of studies have investigated the relation between production and technological specialisation. Thus, Amendola *et al.* (1992) and Soete and

Verspagen (1994) present, respectively, cross-section regression estimates, country-wise across sectors or sector-wise across countries, of equations relating the level of revealed comparative advantage of the value of exports to a patent-based measure of revealed comparative performance of research efforts. Their results show that the relation between both is positive and statistically significant in most cases. The latter authors also present estimates of similar regressions relating export specialisation, in turn, to investment intensity and to wage costs, and show that the latter variables are, on average, each time far less significant. Their results show also that the stronger performance of comparative research efforts is, especially, the case in research intensive industries.

But, by only considering single variable equations, these studies can, at most, provide estimates of the direct correlation between the variables concerned. Moreover, by including in the equations the revealed comparative advantage and performance indicators in raw data as such, rather than in a transformed manner, the presented t-values are likely to suffer from a problem of non-normality of the regression residuals and are, therefore, rather unreliable. The latter is somewhat less the case for the country-wise correlation analysis between value added and R&D expenditure based measures of RCA presented in Frantzen (2005), where the variables are expressed in log form. Also here the evidence is of a significant positive correlation in most countries. But, again, it concerns only direct correlations and log transforms are, as mentioned below, not without their own problems.

Wolff (1997) does, for its part, present multiple regression sector-country cross-section estimates of equations relating the rate of growth of revealed comparative advantage of real value added and of the value of exports to that of revealed comparative performance indicators of wage costs, physical capital intensity and TFP. His results indicate that the impact of comparative TFP performance dominates that of the other variables, and that this dominance is clearly stronger in the case of value added specialisation than in the case of export specialisation. These results are, however, unreliable since, by omitting a comparative research efforts variable, part of its impact is captured by comparative TFP. Moreover, by using a measure of revealed comparative advantage based on real value added (value added in constant prices) rather than actual value added, this is likely to cause an upward simultaneity bias in the parameter estimate of comparative TFP, since the TFP figures are, themselves, based on the same real value added data.

III. METHODOLOGY

III.1. *Specialisation*

In order to study specialisation, we will follow common practice in the empirical literature and use Balassa's (1965) Revealed Comparative Advantage (RCA) index as a central indicator. Since there may be differences between the patterns of specialisation of total production and exports, we will base it, in turn, on manufacturing value added data and on manufacturing export value data, and thus obtain RCAV and RCAE indexes as:

$$RCAV_{ijt} = \frac{V_{ijt} / \sum_j V_{ijt}}{\sum_i V_{ijt} / \sum_i \sum_j V_{ijt}} \qquad RCAE_{ijt} = \frac{E_{ijt} / \sum_j E_{ijt}}{\sum_i E_{ijt} / \sum_i \sum_j E_{ijt}} \tag{1}$$

where V_{ijt} stands for nominal value added at factor costs in common currency in sector j in country i at time t, and E_{ijt} for the corresponding value of exports. The RCA indexes are based on a comparison of the national production structure (the numerator) with the international aggregate production structure (the denominator). When RCA equals 1 for a given sector in a specific country, the percentage share of that sector is identical to the international average. When RCA is above 1 the country is said to be specialised in this sector, and vice versa when it is below 1. The degree of dispersion of the RCA figures provides an estimate of the average level of specialisation. We will study its evolution through time and we will analyse the stability of the specialisation patterns by means of a regression analysis relating the RCA figures at different points in time.

It should be noted that, when considered as such, the RCA indexes take values between zero and infinity, with a (weighted) average of 1 (the case of neutral specialisation). They are, therefore, asymmetric in nature. In order to avoid the problems caused by this, we will consider the Revealed Symmetric Comparative Advantage transforms, RSCA=(RCA-1)/(RCA+1), of the RCA indexes when studying their degree of dispersion and stability through time.

III.2. *Econometric models*

The autoregressive equation used to study the stability of the manufacturing production specialisation patterns is estimated on 5-yearly annual panel data. In the case of value added specialisation it is given by:

$$RSCAV_{ijt} = \varphi + \mu RSCAV_{ijt-1} + \varepsilon_{ijt} \qquad (2)$$

where $RSCAV_{ijt}$ stands for the RSCAV index of sector j in country i at time t; t-1 stands for t five years earlier; φ is an intercept, μ the autoregressive coefficient and ε_{ijt} a sector-country specific stochastic error term. In the case of export specialisation the equation is similar and now relates $RSCAE_{ijt}$ to $RSCAE_{ijt-1}$, where $RSCAE_{ijt}$ stands for the RSCAE index of sector *j* in country *i* at time *t*.

If the autoregressive coefficient is positive ($\mu > 0$), this means that the specialisation pattern is cumulative in nature. Provided that this is so, one can still distinguish 3 possibilities. If $\mu = 1$, this means that the specialisation pattern is sticky, in the sense that it remains unchanged apart from its stochastic element, ε_{ijt}. If $\mu > 1$, this implies that the degree of specialisation is incremental, in the sense that it further increases in sectors where the country was already specialised. If $0 < \mu < 1$, this indicates that, although the specialisation pattern is positively related to past specialisation, the degree of specialisation decreases. We will call this μ-convergence of the specialisation patterns. This is similar to the concept of β-convergence in the case of productivity convergence analysis. The magnitude 1- μ provides an estimate of the size of the convergence effect, or of the regression effect towards the mean.

The corresponding Pearson correlation coefficient, R, measures the extent to which the relative position of the respective industries remains unchanged in terms of RSCA values. The magnitude 1-R therefore measures the mobility effect. By taking the variance of Equation (2), re-arranging terms, taking the square root and leaving out sector and country subscripts, one obtains, most interestingly: $\mu / \mathrm{R} = \sigma_t / \sigma_{t-1}$ where σ_t stands for the standard deviation of RSCA at time *t*. This proportion will, therefore, confirm whether there is σ-convergence in specialisation, or not.

After studying their main features, we will then attempt to explain manufacturing value added and export specialisation themselves. A starting point for doing so can be to first concentrate on relative unit labour costs and relative research efforts, since these are generally viewed as the major determinants of international cost and product qualitative competitiveness. Countries would, according to this logic, specialise in those manufacturing sectors where they possess a comparative advantage in terms of unit labour cost (ULC) and research performance. If we measure research efforts by R&D expenditure, a long-run relation aimed at explaining production specialisation can thus be obtained as:

$$RSCAV_{ijt} = \psi + \xi RSCAU_{ijt} + \theta RSCAR_{ijt} + \varepsilon_{ijt} \tag{3}$$

where $RSCAV_{ijt}$ stands for the revealed symmetric comparative advantage index of the value added in sector *j* in country *i* at time *t*; $RSCAU_{ijt}$ and $RSCAR_{ijt}$ stand for the respective corresponding revealed symmetric comparative performance indexes of ULC and R&D expenditure, both constructed in a similar manner as in the case of the RSCAV; and ε_{ijt} is, again, a sector-country specific stochastic error term. In the case of exports, the corresponding equation has the $RSCAE_{ijt}$ index as its l-h-s variable.

Considering a ULC-based comparative performance indicator as such may, however, not be very illuminating, since measured ULC is the result of the underlying influence of its component parts. The ULC is, by definition, equal to the wage cost per worker divided by the output per worker, or labour productivity. If one assumes a production function that relates output to physical capital and labour, augmented by a variable reflecting the level of TFP, labour productivity can, itself, be expressed as a function of the level of physical capital intensity (capital per worker) and the level of TFP. It will, therefore, also be useful to estimate a second equation in which the $RSCAU_{ijt}$ variable is replaced by the revealed symmetric comparative performance indexes of wage costs, physical capital intensity and TFP, such as:

$$RSCAV_{ijt} = \psi + \alpha RSCAW_{ijt} + \delta RSCAK_{ijt} + \gamma RSCAA_{ijt} + \theta RSCAR_{ijt} + \varepsilon_{ijt} \qquad (4)$$

where $RSCAW_{ijt}$, $RSCAK_{ijt}$ and $RSCAA_{ijt}$ stand for the respective revealed symmetric comparative performance indexes of wage costs, physical capital intensity and TFP, again constructed in a similar manner as in the case of RSCAV. In the case of exports, the corresponding equation has the $RSCAE_{ijt}$ index as its l-h-s variable.

If, as assumed by the standard neo-classical Heckscher-Ohlin-Samuelson theory of international trade, technology is equally accessible across countries and there is factor price equalisation, production specialisation will only depend on countries' revealed comparative advantage in terms of capital intensity, which is, itself, determined by their relative factor endowments of capital and labour. In the case of Equation (4) only $RSCAK_{ijt}$ will matter and in Equation (3) only $RSCAU_{ijt}$ will do so, and this exclusively due to its capital intensity component. In the case of the Heckscher-Ohlin theorem without factor price equalisation, also the comparative wage cost performance, $RSCAW_{ijt}$, will matter in Equation (4), and the $RSCAU_{ijt}$ variable in Equation (3) will also be affected by its wage component.

If we relax the assumption of equal accessibility of technology across countries, also the comparative technological performance variables will matter, as stressed by Schumpeterian theory. To the extent that TFP would, itself, exclusively be determined by research efforts, including the measure of revealed comparative performance of R&D expenditure, $RSCAR_{ijt}$, in Equation (4) will suffice. But, to the extent that TFP is also affected by other influences, it is useful to include both revealed comparative performance measures of TFP and of research efforts in Equation (4). We think here at the impact on our measured comparative TFP of differences in comparative labour skills, which could not be included due to lack of data. Further, and even more important, TFP performance may also be the result of dynamic economies of scale due to learning-by-doing, as stressed by 'new trade theory'.

Whereas one should expect the coefficients of the comparative performance of capital intensity, TFP and research expenditure, δ, γ and θ, to be positive, the sign of the coefficient of comparative wage costs, α, may either be negative or positive. A wage cost competitiveness effect would imply a negative sign of α. A positive sign of α is however also possible, to the extent that differences in labour skills are reflected in wage differentials and that labour skills affect product quality. Firms may, moreover, deliberately apply wage policies aimed at stimulating efficiency and quality of work (see, especially, Akerlof and Yellen, 1986). The actual sign of the estimated coefficient of $RSCAW_{ijt}$, α, will, therefore, depend on whether the labour skill and efficiency wage effect (implying a positive relation) dominates the more traditional wage cost competitiveness effect (implying a negative relation), or otherwise. A positive net impact of comparative wages may even imply a positive sign of the coefficient of the measure of comparative ULC, ξ, in Equation (3), to the extent that it is stronger than the joint impact of the determinants of comparative labour productivity, $RSCAK_{ijt}$ and $RSCAA_{ijt}$.

Finally, it should be noted that the partial shifting by firms of changes in unit labour costs into prices will have a positive short run effect on output values. This should increase somewhat the positive impact of comparative wage costs and diminish that of comparative capital intensity and TFP, but this effect is likely to be modest due to our specification of the equations in level terms.

III.3. *Methods of estimation*

As mentioned in the Appendix, the countries and the level of aggregation of the industries considered in this study were chosen for reasons of data availability. The 14 countries concerned can be viewed as representative for the developed economies, as they account for more than 90% of the manufacturing value added and for more than 95% of the R&D expenditure in the OECD.

Since, as mentioned above, the untransformed RCA indexes are asymmetric in nature, if used as such in a regression analysis this poses a problem of lack of normality of the stochastic error term, leading to unreliable t-statistics. One manner of reducing this problem could have been to express the RCA indexes in logs. But this raises the problem that small absolute values of RCA become highly negative log values. This will especially affect the regression estimates of the intercept terms in the equations, making them highly sensitive to errors of measurement in the data. Preference was, therefore, given to the use of the revealed symmetric comparative advantage transform, RSCA, such as proposed by Dalum *et al.* (1998).

The purpose of the autoregressive Equation (2) is to analyse the degree of stability of the specialisation pattern during the considered medium-run period of investigation. It is estimated on 5-yearly panel data. Comparable equations are also estimated, in turn, on the r-h-s variables of Equations (3) and (4) in order to study their stability through time. Estimation was, each time, first performed country-wise across sectors and sector-wise across countries, and then repeated on the pooled panel. Since we want to investigate the presence of a regression effect toward the mean (or, in other words, unconditional μ-convergence), the country-wise and sector-wise equations are estimated with a single intercept and without control variables. This is also the case of the estimates on the pooled data, which are aimed at depicting the average tendencies. Finally, since there was no evidence of serial correlation in the error terms, Equation (2) could be estimated by straight ordinary least squares (OLS).

The purpose of Equations (3) and (4) is, for their part, to estimate the long-run relation between production specialisation and a series of revealed comparative performance indicators. They are, therefore, specified as relations between variables in level terms, and, in order to exploit all available information, they are this time estimated on yearly panel data. Since it is highly unlikely at the considered level of aggregation that countries will become ever more specialised between industries, we do not expect the data to contain stochastic trends. OLS estimates should, therefore, not be affected by a spurious correlation due to non-stationarity of the data.[1]

Estimation of Equations (3) and (4) by means of OLS may, however, pose other problems. In order to obtain reliable parameter estimates and standard errors for drawing statistical inference, the r-h-s variables in the equation should at least be weakly exogenous and the regression error terms should be serially independent. Neither of these conditions may, however, apply.

The existing pattern of comparative TFP performance may itself, in part, be the result of past dynamic economies of scale through learning-by-doing. In the same vain, there may also be feedback effects from production specialisation to research expenditure and capital intensity, since the higher income in the sectors concerned may allow to

[1] Ideally, we would like to seek explicit confirmation of this by means of a unit root analysis. But this may be difficult, since, as seen below, the data appear to be partly determined by transitional dynamics during the period of investigation. Unit root tests may, under such circumstances, misread these temporary movements as stochastic trends.

undertake larger research efforts and capital investment. This would, each time, imply a degree of endogeneity of the variables concerned and, therefore, a level of simultaneity in our considered long-run static relation. This simultaneity may be especially strong if the economic agents are able to anticipate to some extent shocks to the environment. Furthermore, since we have, most likely, only considered some of the variables concerned, the missing influences will, necessarily, be captured by the residual error term in the regression. To the extent that these missing variables are, themselves, serially correlated through time, so will the residual errors.

Applying an instrumental variable technique, in order to handle the simultaneity problems, may not be feasible, due to a lack of adequate exogenous variables on which to base the instruments. Simply basing these on lagged values of the variables concerned, which is often done in such case, is only an option provided that the regression error terms are serially independent. But, as seen in Table 5 below, this is clearly not the case.

It, therefore, appears that the best we can do in order to handle these problems is to apply a dynamic ordinary least squares (DOLS) procedure. This consists 1) in estimating by OLS an extended regression, which includes, besides our r-h-s variables, concurrent, lagged and lead values of their first differences, and 2) in estimating the standard errors on the basis of a long-run serial correlation robust error variance-covariance matrix. The simultaneity bias are attenuated by the inclusion of these dynamic terms, which help to clean, so-to-speak, the error term from its correlation with our r-h-s variables, and the serially correlation robust standard errors allow to obtain reliable t-tests for drawing statistical inference.

We will start by estimating our base-line Equations (3) and (4) as such in order to obtain a general idea of the average parameter values for the entire sample. In order to analyse systematic differences in behaviour between subsets of the sample, we will then extend them by including dummy variables and dummy interaction shift terms, and also re-perform estimation on the sub-samples concerned. Since we are likely to be missing some systematic country-specific and sector-specific un-measurable institutional influences on the specialisation patterns, we will, as a check of robustness, also repeat estimation by including country-specific and sector-specific intercepts.[2]

IV. ESTIMATES

Table 1 presents raw estimates of the RCAV and RCAE indexes, based on manufacturing value added and export data.

Tables 1

The figures are presented country-wise and relate respectively to the first and to the last year of our period of investigation. Due to space constraints, only the highest and the lowest 4 RCA figures are each time presented with respect to 7 out of the 14 countries under consideration. Consider first the results with respect to value added in 1970. A comparison between countries clearly shows that developed economies have very different specialisation patterns in terms of manufacturing value added. As expected, the

[2] It should be noted that we will, however, not make use of a fixed effects specification (including a separate intercept for each country-sector in the panel), since such fixed effects would capture part of the impact of the most sticky r-h-s variables. This would provide a totally distorted picture of the relative importance of the respective variables. A random effects panel data estimation procedure is equally unsuitable for our purpose, since our sample of developed economies is not drawn randomly from a large population of such economies, but it covers nearly the entire population.

smaller economies appear, to be more specialised than the larger ones (larger highest RCAV figures and smaller lowest ones).

The RCAV figures with respect to 1995 lead to similar conclusions. Comparing the results of both years with one another gives a clear hint of a relatively substantial degree of stability in the specialisation patterns: about 2/3 of the sectors found in the top-4 or in the bottom-4 of the RCAV rankings in 1970 were still found so in 1995. But, at the same time, there is also evidence of a degree of mobility, as in 1/3 of the cases other sectors entered the top-4 or bottom-4, and even when the same sectors remained, their specific individual ranking sometimes changed.

The RCAE figures, presented in the second part of Table 1, provide a quite similar picture with respect to export specialisation. If anything, the average degree of specialisation seems even larger in the case of exports than in the case of value added (higher top-4 and lower bottom-4 values in the case of exports). There are also differences in the composition of the top-4 and bottom-4 groupings, indicating that, although they possess similar properties, both specialisation patterns are quite distinct.

In order to assess more precisely the average degrees of manufacturing production specialisation, we have estimated the country-wise standard deviations of the RSCAV and RSCAE figures across sectors and the corresponding sector-wise standard deviations across countries. Due to space constraints, we only present the mean values in the first four rows of Table 2.

Table 2

It is clear that these average standard deviations are substantial. This confirms the general hint, given by the raw RCAV and RCAE data in Table 1, that the degree of specialisation of manufacturing production of developed economies is substantial. As suggested by that table, it is even somewhat higher in the case of exports than in the case of value added. A closer consideration of the (non-presented) underlying country-wise results also confirms that the average degree of specialisation is especially strong in the smaller economies of the sample. Moreover, a comparison of the standard deviations through time in Table 2 shows that they remain relatively constant. In the case of *RSCAV* there is no evidence of σ-convergence at all, whereas in the case of *RSCAE* there is only a modest evidence of such convergence.

But what about the precise correlation between the specialisation patterns through time? In order to study this, we estimated the autoregressive Equation (2) on separate panels country-wise across sectors and sector-wise across countries, as well as on the pooled total sector-country panel. Although not presented due to space constraints, the country-wise and sector-wise results showed that the autoregressive coefficient, μ is systematically found positive and statistically significant, confirming the hypothesis of cumulativeness of the specialisation patterns through time. The hypothesis that μ is equal to 1 could be rejected in favour of the alternative that it is significantly smaller than 1 in about half of the cases in the case of value added and in about 70% of the cases in the case of exports, whereas it could not in the remaining ones. These results are confirmed by the estimates on the pooled panel presented in the first two rows of Table 3.

Table 3

These estimates imply a modest tendency of μ-convergence in production specialisation patterns. In the case of value added this occurs with a very low average yearly convergence speed, λ, of about 1.3% a year. The corresponding average proportion of

μ/R is close to 1, confirming the noticed constancy of the average degrees of dispersion of *RSCAV* in Table 2. In the case of exports the average yearly convergence speed of 2.2% a year is slightly higher, and the average proportion of μ/R is slightly lower than 1, confirming the modest decrease in the average degrees of dispersion in Table 2. The mobility effect appears, in other words, just sufficient to compensate the impact of a modest regression effect towards the mean in the case of value added, whereas it appears nearly sufficient to do so in the case of exports.

Before turning to the explanation of the manufacturing production specialisation patterns by means of Equations (3) and (4) itself, it is useful to study the behaviour of their r-h-s variables by a comparable analysis as used for the revealed symmetric comparative advantage indexes of value added and exports, *RSCAV* and *RSCAE*. Table 2 presents, therefore, also the means of the standard deviations of these r-h-s variables, and Table 3 the corresponding autoregressive coefficients estimated on the pooled total sector-country panel. The results with respect to the revealed symmetric comparative performance of ULC, *RSCAU,* as well as of its components, *RSCAW, RSCAK, RSCAA,* show each time clear evidence of a substantial degree of μ-convergence, and of a pattern of σ-convergence, which tends to peter-out during the 1980s or at the beginning of the 1990s. This confirms *a priori* expectations in this respect, in view of the evidence of comparable patterns of convergence of the underlying wage cost, capital intensity and TFP variables themselves. These convergence tendencies have been explained by the mechanisms of gradual factor price equalisation, capital accumulation under conditions of decreasing returns to capital, international technological diffusion under decreasing returns to imitation, or flattening of the learning curves in the case of learning-by-doing.

The petering-out of the convergence processes confirms that we are noticing transitional dynamics, and the evidence that, although clearly smaller than in the case of the revealed symmetric comparative advantage of value added and exports, the standard deviations remain, nevertheless substantial at the end of the period of investigation, suggests that the convergence is, most likely, only conditional in nature. This would need further investigation by introducing control variables in the autoregressive equations.

In sharp contrast to this, in the case of the revealed symmetric comparative performance of R&D efforts, *RSCAR*, the $\tilde{\mu}$convergence is much more modest, in the same order of magnitude as in the case of *RSCAE.* The mean values of the standard deviations are now even somewhat larger than in the case of *RSCAE,* and equally sticky as in the case of *RSCAV*. The mobility effect is also now seen to compensate the modest regression effect towards the mean, so that there is no evidence of σ-convergence. It would appear that this broad similarity in behavioural patterns provides, by itself, already a hint of the importance of comparative R&D efforts for explaining production specialisation.

Another hint in this direction can be obtained by considering the direct correlations between the l-h-s and the respective r-h-s variables of Equations (3) and (4) in turn. Table 4 presents the Pearson correlation coefficients between these variables estimated on our total panel.

Table 4

The results indicate that the correlation between the revealed symmetric comparative advantage of the value added and exports, *RSCAV* and *RSCAE,* and that of the comparative performance of R&D efforts, *RSCAR,* is, on average, by far the strongest.

The correlation of *RSCAV* and *RSCAE* with the revealed symmetric comparative performance of ULC, *RSCAU*, is, on average, negative and much lower.

Of its component terms, comparative TFP, *RSCAA,* appears to be best correlated with *RSCAV*, whereas comparative capital intensity, *RSCAK,* is seen to best correlated with *RSCAE.* The worse correlation of *RSCAA* with *RSCAE* can, most likely, be explained by data measurement problems, since the measure of TFP underlying the *RSCAA* variable is, itself, based on real value added figures, and not on real export data, which are not available. It should, therefore, be more suitable for explaining value added specialisation than export specialisation. Finally, the correlation between value added and exports, *RSCAV* and *RSCAE,* and comparative wage costs, *RSCAW,* is, interestingly enough, each time positive. This provides a first crude indication that the labour skill and efficiency wage effect dominates, on average, the wage cost competitiveness effect. But it could, however, also be explained, in part, by a spurious correlation, in the sense that both production specialisation and comparative wages may be positively affected by comparative labour productivity.

Table 5 presents the results of estimation of Equations (3) and (4) on the total panel.

Table 5

Equations (i) and (ii) are Equations (3) and (4) as such, estimated by DOLS. Consider first the results with respect to value added specialisation. The adjusted R^2, presented below, may not appear to be very high for equations with variables in level terms. But they are quite reasonable, in view of the errors of measurement at the considered level of disaggregation, and the fact these base-line equations are only aimed at capturing average effects and are, therefore, estimated with common intercepts and coefficients. The serial correlation test shows, as expected, that the uncorrected regression residuals are serially correlated, thereby justifying the use of a serial correlation consistent error variance-covariance matrix in the DOLS procedure.

As far as the parameter estimates themselves are concerned, it immediately strikes the eye that the signs and the relative contribution of the respective r-h-s variables conform remarkably well with the direct correlations with the l-h-s variable, presented in Table 4. The revealed symmetric comparative performance of R&D efforts, *RSCAR,* is, as expected, by far the most statistically significant variable in both equations (i) and (ii). Even if one could possibly question the capability of our DOLS method in fully controlling for the simultaneity bias caused by some reverse causation, it is, however, difficult to think of manners by which such reverse causation could explain this much stronger correlation of production specialisation with R&D specialisation than with the other comparative performance variables. There is no logical reason why the possible feedback effect from income to research expenditure should, for instance, be stronger than that from income to physical capital expenditure, and so, to capital intensity. Only a causal interpretation along Schumpeterian lines appears to be able to explain this much stronger correlation between production specialisation and R&D specialisation.

The impact of comparative ULC, *RSCAU,* in equation (i) is negative and significant, and this, despite the fact that the impact of comparative wage costs, *RSCAW,* is positive and significant in equation (ii). This is so because the determinants of comparative labour productivity, comparative capital intensity and TFP, *RSCAK* and *RSCAA,* exercise a stronger joint influence on *RSCAV* than comparative wage costs, *RSCAW*. This is especially due to comparative TFP. This is interesting since this variable remains significant in this multiple regression framework, despite that we are now controlling for the possible indirect effect of comparative R&D efforts through comparative TFP on value added specialisation. This confirms *a priori* expectations that there is a net effect of comparative TFP on value added specialisation, because TFP is, itself, in part explained by something else than by R&D efforts, such as labour skills and, especially, learning-by-doing. The evidence that comparative wage costs, *RSCAW,* has a positive significant coefficient, confirms its positive direct correlation with value added specialisation in Table 4. Also this is interesting, since this remains so, despite that we are now including comparative TFP and capital intensity terms among the r-h-s variables. This suggests that the positive direct correlation between comparative wages and value added specialisation is not due to a spurious correlation, as considered above. It gives a clear further hint that we are, indeed, capturing a labour skill and wage efficiency effect that dominates the wage cost competitiveness effect.

The corresponding results with respect to export specialisation are, broadly speaking, quite similar. In this case the intercept term in equation (i) and (ii) is, however, somewhat lower (more negative). This reflects the fact that the average degree of export specialisation is even stronger than that of value added specialisation (more sectors with measured RCAE indexes close to zero and, therefore, negative values of *RSCAE*). Again, comparative R&D efforts, *RSCAR,* is by far the most statistically significant variable. As suggested by the direct correlation in Table 4, in the case of exports, of the cost terms, comparative capital intensity, *RSCAK,* is found to exercise the strongest influence on specialisation, whereas comparative TFP, *RSCAA,* is non-significant – a result most likely caused by measurement problems. The influence of comparative wage costs, *RSCAW,* is, again positive, suggesting a dominance of the labour skill and efficiency wage effect. Finally, in the case of exports, the impact of comparative ULC, *RSCAU,* is found non-significant in equation (i), due to the non-significance of comparative TFP, *RSCAA,* in equation (ii).

In order to assess the possible impact of un-measurable institutional influences on the specialisation pattern, we have, each time, repeated estimation by including country-specific and sector-specific intercepts in Equations (3) and (4). The results are presented in equations (iii) and (iv) in Table 5. Although this improves the statistical fit, it does, however, hardly affect the parameter estimates, thereby confirming the robustness of our results in this respect.

Table 6 investigates the differences in behaviour between large and small economies.

Table 6

Equations (i) is Equation (4) estimated on the total sample, with a *dumG7* dummy variable included that takes value 1 for the G7 economies and 0 otherwise, as well as *dumG7* interaction shift terms of this dummy with the other variables. Whereas equations (ii) and (iii) are Equation (4) as such estimated on the G7 and Non G7 sub-samples. The first thing to notice is that, both for value added and for exports, the intercept is, each time, significantly lower in the case of the Non G7 economies, than in the case of the G7 economies. This reflects the stronger degree of specialisation of the small economies (many sectors with RCAV and RCAE close to 0 and, therefore, negative *RSCAV* and *RSCAE* values).[3]

As far as the estimated coefficients are concerned, although the main explanatory variable is each time comparative R&D efforts, *RSCAR,* its impact is significantly stronger in the case of the Non G7 or smaller economies. This can be seen as reflecting the fact that, in view of the important fixed costs in the research sphere, small economies tend to concentrate their more limited means on a more limited number of sectors in order to build-up the necessary comparative advantages. Smaller developed economies have, therefore, not only more specialised manufacturing production specialisation patterns than the larger ones, but the impact on these of their comparative R&D efforts is even stronger.

Finally, Table 7 examines the differences in behaviour between research intensive and less research intensive manufacturing sectors. These sectors are indicated in the Appendix.

Table 7

Equation (i) is equation (4) estimated on the total sample, with a *dumRI* variable included that takes value 1 for the research intensive sectors and 0 otherwise, as well as interaction terms of this dummy with the other variables. Whereas equations (ii) and (iii) are Equation (4) as such, estimated on the research intensive and non research intensive sub-samples. The first thing to notice is that, both for value added and for exports, the intercept is significantly smaller in research intensive sectors, reflecting the stronger

[3] This is confirmed by the fact that the average values of the mean of the country-wise standard deviations of *RSCAV* and *RSCAE* for the years considered in Table 2 are, respectively, 0.322 and 0.379 for the Non G7 countries, against 0.194 and 0.287 for the G7 countries.

degree of specialisation in the research intensive sub-set of manufacturing.[4] Furthermore, although the main explanatory variable is, each time, comparative R&D efforts, its influence is significantly stronger in the case of the research intensive sectors.

As far as the cost variables are concerned, there is a striking difference between research intensive and non research intensive sectors. Comparative wage costs, *RSCAW,* is each time seen to have a positive significant impact on specialisation in the case of research intensive industries, whereas its impact is either significantly negative or non significant in the case of non research intensive industries. The influence of comparative capital intensity and comparative TFP is, for their part, each time significantly stronger in the non research intensive sectors. These results stress that the dominance of the impact of the product qualitative aspects of competitiveness on production specialisation is strongest in the research intensive industries. The stronger specialisation in the research intensive sub-set of manufacturing can, for its part, best be explained by the existence of more important dynamic economies of scale in the research sphere in these industries.

V. SUMMARY AND CONCLUSIONS

The relation between technology and manufacturing production specialisation in developed economies was studied on a sample of panel data with respect to 14 OECD countries and 22 sectors during the period 1970-1995. Use was thereby made of models relating indicators of revealed symmetric comparative advantage of value added and

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[4] This is confirmed by the fact that the average values of the mean of the country-wise standard deviations of *RSCAV* and *RSCAE* for the years considered in Table 2 are, respectively, 0.255 and 0.350 for the RI sectors, against 0.218 and 0.316 for Non RI sectors.

exports to comparable measures of comparative performance of R&D expenditure, ULC and of its component terms – capital intensity, TFP and wage costs.

The study of the behaviour of the standard deviations of the variables concerned and estimates of corresponding autoregressive equations showed that the manufacturing production and R&D specialisation are each time substantial and sticky. This contrasts with the lower degree of dispersion and the substantial convergence in the patterns of the respective comparative cost terms. This provides a first hint of the importance of the relation between R&D and production specialisation.

A further hint of this is given by a direct correlation analysis between the variables concerned, which shows that the correlations between comparative value added and exports and comparative R&D expenditure are, by far, the strongest. This is then confirmed by multiple regression estimates of the models, which show, each time, a clear dominance of the impact of comparative R&D expenditure over the other considered explanatory variables.

Of the component cost terms, comparative TFP is found to exercise the strongest impact on value added specialisation. The fact that this variable does so, despite the inclusion of a comparative R&D efforts variable, suggests that we are capturing a net effect. The evidence that this is less so in the case of export specialisation, where comparative capital intensity is found most important among the cost component terms, has more than likely to be explained by problems of measurement. The impact of comparative wage costs is, for its part, each time found to be positive, suggesting that the labour skill and efficiency wage effect dominates the wage cost competitiveness effect.

A comparison between the behaviour of the small and large economies in the sample shows that the smaller economies are more specialised in their manufacturing production than the larger ones. The impact of comparative R&D efforts on production specialisation is, in their case, even found to be stronger.

Finally, a comparison between the behaviour of research intensive and less research intensive sectors shows that the former are more specialised. Although comparative R&D expenditure is, each time, the most important explanatory variable, its influence is strongest in the research intensive sub-set of manufacturing.

When viewed in the light of the theoretical literature, our main finding of the dominance of our measure of technological specialisation over the other explanatory variables is perfectly in line with the predictions of Schumpeterian theory. The extent and the stickiness of the manufacturing production specialisation of developed economies can, in this sense, in the first place be explained by the extent and stickiness of its technological specialisation. This is, itself, a reflection of the cumulative nature of knowledge and its only partial and gradual dissemination through technological diffusion. The evidence that this dominance is strongest in the most research intensive industries further strengthens this interpretation. And this is also the case for the finding that it is especially here that the labour skill and efficiency wage effect is more important than the wage cost competitiveness effect, in the sense that this confirms the role of product qualitative aspects of competitiveness in helping production specialisation is strongest in these industries.

The evidence of a net effect of comparative TFP can, for its part, most plausibly be explained by the presence of a dynamic economies of scale effect due to learning-by-doing, such as stressed by ‘new trade theory’. Finally, the findings of a stronger degree of specialisation and a stronger impact of comparative R&D in the smaller economies, and of a stronger specialisation in the research intensive industries, can all be explained in the light of those contributions to ‘new trade theory’ that have stressed the importance of dynamic economies of scale due to fixed costs in the R&D process. Due to their more limited means, smaller economies have to concentrate these on a more limited number of sectors, in order to build-up the necessary comparative advantages. Their production specialisation will, therefore, not only be higher, but also more affected by their technological specialisation. Higher fixed costs in the R&D process of research intensive industries do, in the same vain, imply a stronger concentration of the available means, and, therefore, a stronger specialisation between sectors in the research intensive sub-set of manufacturing.

When considered in conjunction, our findings clearly suggest that the growing intuitive awareness in economic policy circles of the importance of the relation between technology and production specialisation appears to be justified. The tentative hints given in this respect by the existing limited empirical literature on the subject are vastly strengthened by the present results. Not only have we shown in a more explicit manner that the stickiness of the production and technological specialisation patterns are related to one another, by contrasting it with evidence of substantial convergence in the patterns of the respective comparative cost variables. But, by considering multiple regression estimates as well as direct correlations, we have been able to provide a much clearer insight in the relative importance of the respective explanatory variables.

Some issues do, however, still deserve further investigation. Although we have been able to identify systematic differences in behaviour between large and small economies, and between research intensive and less research intensive manufacturing industries, we expect that there is still quite some heterogeneity in behaviour within these groupings. Estimation should, therefore, be repeated while concentrating on the country-wise and sector-wise levels. Furthermore, our evidence of significant unexplained country-specific and sector-specific intercept terms does suggest that not directly measurable institutional features are playing a part. It would appear that, in order to gain further insight in this, the econometric analysis should be complemented by a more detailed descriptive historical case study approach.

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APPENDIX

The 14 countries considered in this study were chosen for reasons of data availability with respect to the variables under consideration. They are Australia, Canada, Denmark, Finland, France, West Germany, Italy, Japan, the Netherlands, Norway, Spain, Sweden, the UK and the USA.[5] Manufacturing is disaggregated into the following 22 sectors (abbreviation, ISIC codes): Food, Beverage and Tobacco (FO, 31), Textiles, Leather and Footwear (TX, 32), Wood and Wooden Products (WO, 33), Paper, Printing and Publishing (PA, 34), Chemicals exclusive Drugs (CH, 351+352-3522)*, Drugs (DR, 3522)*, Petrochemicals (PET, 353+354), Rubber and Plastic Products (RP, 355+356), Non Metallic Minerals (NM, 36), Steel (ST, 371), Non Ferrous Metals (NF, 372), Simple Metal Products (MET, 381), Machinery (MA, 382-3825)*, Computers (CO, 3825)*, Electrical Goods (EG, 383-3832)*, Radio, TV and Telecommunication Equipment (CE, 3832)*, Ships and Boats (SH, 3841), Automobiles (AUT, 3843)*, Aerospace (AE, 3845)*, Other Transport Equipment (OTR, 384-3841-3843-3845)*, Instruments (IN, 385)*, Other Manufacturing (OTM, 39). Sectors where the average proportion of R&D expenditures over value added during the period of investigation exceeds 5% in the US, Japan and Germany are defined as research intensive and indicated by an asterisk.

The data with respect to nominal value added (value added at factor costs in current prices), V_{ijt}, the value of exports, E_{ijt}, real value added or income (value added at factor costs in constant prices of 1970), Y_{ijt}, labour (employment), L_{ijt}, wage costs, W_{ijt}, and thus unit labour costs, $W_{ij}/(Y_{ij}/L_{ij})$, used in the construction of our revealed comparative performance indexes of value added, exports, wage costs and unit labour costs, were all obtained from the *OECD STAN Database*.

The use of nominal, rather than real figures in the construction of our revealed comparative advantage of value added and exports indexes, RCAV and RCAE, is justified in order to better take account of product qualitative changes, to the extent that

[5] After reunification the German data relate to the Western part of Germany, corresponding to previous West Germany.

these are reflected in price changes. It should further be noted that the value of exports, E_{ijt}, are gross value figures, including, besides value added, also the value of material inputs obtained from upstream sectors or imported from abroad. In principle, export value added figures should have been preferred for constructing our RCAE index, since they better capture the relative importance of the sectoral activities concerned. But the necessary value added data are only available for total sectoral production, and not for its home market and export components. It is, however, unclear whether the standard deviation of the RSCAE would have been smaller or larger if RSCAE had been based on export value added figures instead. It appears, reasonable, to view the evidence of systematic differences in the measured degrees of specialisation of total value added and exports as in the first place reflecting behavioural differences between total production, and, therefore, home market production specialisation and export specialisation.

In the case of the revealed comparative performance index of physical capital intensity, we do not dispose of readily available physical capital stock series, K_{ijt}, and therefore of capital intensity, K_{ijt}/L_{ijt}, at the considered level of aggregation. The *STAN Database* does, however, contain figures on nominal capital investment. We had, therefore, first to deflate these in order to obtain figures in real terms. We did so by using the business sector value added price deflator, obtained from the *OECD Business Sector Database.* We then constructed the corresponding capital stock figures by applying the perpetual inventory method, while using a depreciation rate of 5%. The chosen rate of capital depreciation of 5% has unavoidably something arbitrary to it. Experimentation with alternate rates of 3 and 7% did hardly affect our results.

The revealed comparative performance of TFP index is based on a TFP construct, $A_{ijt} = (Y_{ijt} / L_{ijt})/(K_{ijt} / L_{ijt})^{\alpha}$, under the assumption of a Cobb Douglas production function with constant returns to scale and Hicks-neutral technical progress. The value of the exponent α was obtained from the regression estimates of a dynamic technology gap model presented in Frantzen (2004). In order to check the robustness of our results, we also experimented with a comparable TFP construct, with a value of α approximated by revenue-based figures on the average capital income share across countries during the period of investigation. Although not presented due to space constraints, the use of this alternate TFP construct did not affect any of our results presented above.

The figures with respect to nominal R&D expenditure, R_{ijt}, underlying our revealed comparative performance of research index were obtained from the *OECD Science and Technology Database* (for 1970) and from the *OECD ANBERD Database* (from 1975 onwards). They cover total sectoral business enterprise R&D expenditures, both on researchers and on capital equipment goods used in the research process.

All nominal figures, with respect to value added, V_{ijt}, the value of exports, E_{ijt}, wage costs, W_{ijt}, and research expenditure, R_{ijt}, are expressed in dollars at current yearly purchasing power parity, PPP. All real figures, with respect to income, Y_{ijt}, and physical capital, K_{ijt}, are, for their part, expressed in dollars at 1990 PPP.

For reasons of data availability, the starting date of the respective series is 1970 and the period of investigation 1970-1995. In some countries entire series of certain variables were missing in certain sectors. These sectors were therefore dropped.

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Table 1. *Country-wise revealed comparative advantage of manufacturing value added and exports (1970, 1995, 22 Sectors)*

		1970				1995			
		(i)	(ii)	(iii)	(iv)	(i)	(ii)	(iii)	(iv)
Value added									
US	highest	AE 1.87	IN 1.45	PA 1.19	MA 1.12	AE 1.66	IN 1.54	PA 1.20	WO 1.16
	lowest	PET 0.65	CE 0.73	NM 0.76	ST 0.80	OTR 0.56	NM 0.64	ST 0.68	EG 0.76
Japan	highest	OTM 1.92	SH 1.54	CE 1.51	ST 1.37	OTM 2.27	ST 1.58	CO 1.52	EG 1.50
	lowest	AE 0.08	PET 0.54	IN 0.63	PA 0.68	AE 0.14	PET 0.51	IN 0.55	WO 0.62
Germany	highest	PET 1.47	CE 1.36	MET 1.29	CO 1.26	PET 1.72	NF 1.50	ST 1.41	AUT 1.40
	lowest	AE 0.17	OTR 0.23	SH 0.33	OTM 0.44	OTM 0.29	PA 0.44	AE 0.51	TX 0.52
UK	highest	OTR 1.62	AE 1.53	SH 1.18	TX 1.14	EG 1.64	AE 1.36	FO 1.27	DR 1.24
	lowest	CO 0.64	WO 0.66	OTM 0.68	IN 0.71	OTM 0.43	IN 0.50	NF 0.54	CE 067
Netherlands	highest	CE 3.12	PET 2.99	SH 2.11	CH 1.57	PET 3.33	SH 2.04	CH 1.82	FO 1.42
	lowest	EG 0.17	OTM 0.27	CO 0.27	AUT 0.29	EG 0.15	AUT 0.26	CO 0.28	OTM 0.31
Finland	highest	PA 2.92	WO 2.50	SH 2.25	OTR 1.21	SH 5.35	PA 2.45	WO 2.01	OTR 1.25
	lowest	CO 0.10	IN 0.17	AUT 0.16	AE 0.18	AUT 0.18	DR 0.33	AE 0.36	OTM 0.35
Norway	highest	SH 5.50	NF 3.08	WO 2.06	OTR 1.72	SH 6.91	NF 2.75	FO 1.88	OTR 1.59
	lowest	CO 0.08	IN 0.09	AUT 0.11	DR 0.18	AUT 0.14	IN 0.29	CO 0.41	TX 0.42

Table 1. *(continued)*

		1970				1995			
		(i)	(ii)	(iii)	(iv)	(i)	(ii)	(iii)	(iv)
Exports									
US	highest	AE	CO	IN	MA	AE	CO	CE	IN
		3.35	1.93	1.35	1.29	2.10	1.45	1.44	1.28
	lowest	OTR	TX	ST	RP	ST	OTR	NM	TX
		0.26	0.26	0.53	0.56	0.30	0.47	0.54	0.64
Japan	highest	OTR	CE	SH	ST	SH	CE	OTR	CO
		2.90	2.53	2.51	2.16	3.09	2.26	2.05	1.57
	lowest	AE	PET	DR	PA	WO	AE	PA	DR
		0.07	0.11	0.27	0.28	0.06	0.06	0.16	0.22
Germany	highest	MA	AUT	EG	MET	MA	AUT	EG	MET
		1.38	1.34	1.28	1.28	1.29	1.23	1.22	1.22
	lowest	AE	FO	PA	SH	CO	SH	PET	AE
		0.20	0.34	0.44	0.52	0.48	0.50	0.54	0.64
UK	highest	OTM	DR	NF	AE	OTM	DR	CO	PET
		2.07	1.54	1.43	1.25	2.47	1.82	1.63	1.22
	lowest	WO	SH	PA	ST	WO	SH	AUT	PA
		0.27	0.56	0.57	0.69	0.29	0.45	0.64	0.82
Netherlands	highest	PET	FO	CH	CE	PET	FO	CH	DR
		3.56	2.74	1.53	1.43	3.34	2.74	1.54	1.26
	lowest	AUT	MA	OTM	WO	AUT	OTM	MA	WO
		0.19	0.40	0.43	0.50	0.27	0.48	0.53	0.53
Finland	highest	PA	WO	SH	NF	PA	WO	SH	ST
		9.62	9.19	2.13	0.98	6.85	4.17	1.87	1.80
	lowest	AE	CO	DR	AUT	AE	OTR	AUT	DR
		0.01	0.02	0.07	0.08	0.04	0.18	0.23	0.30
Norway	highest	NF	SH	PA	FO	SH	NF	PA	FO
		6.07	4.71	3.03	1.34	7.88	7.09	1.88	1.62
	lowest	AUT	CO	OTM	IN	AUT	OTR	OTM	DR
		0.08	0.10	0.14	0.17	0.15	0.21	0.29	0.31

Notes: Abbreviations: Food, Beverages and Tobacco (FO), Textiles, Leather and Footwear (TX), Wood and Wooden Products (WO), Paper, Printing and Publishing (PA), Chemicals exclusive Drugs (CH), Drugs (DR), Petrochemicals (PET), Rubber and Plastics (RP), Non Metallic Minerals (NM), Steel (ST), Non Ferrous Metals (NF), Simple Metal Products (MET), Machinery (MA), Computers (CO), Electrical Goods (EG), Radio, TV and Telecommunication Equipment (CE), Ships and Boats (SH), Automobiles (AUT), Aerospace (AE), Other Transport Equipment (OTR), Instruments (IN), Other Manufacturing (OTM).
The measure of revealed comparative advantage is Balassa's (1965) Revealed Comparative Advantage index. Only the highest 4 figures (in decreasing order) and the lowest 4 figures (in increasing order) are each time presented with respect to 7 out of the 14 countries under consideration.

Table 2. *Mean of the country-wise and sector-wise standard deviations of the revealed symmetric comparative performance of value added, exports, wage costs, capital intensity, tfp, ulc and R&D expenditure (22 sectors, 14 countries)*

Variable	1970	1975	1980	1985	1990	1995
	(i)	(ii)	(iii)	(iv)	(v)	(vi)
RSCAV						
count.wise	0.260	0.246	0.250	0.261	0.263	0.269
sect. wise	0.235	0.230	0.228	0.235	0.234	0.248
RSCAE						
count.wise	0.342	0.334	0.334	0.349	0.325	0.317
sect. wise	0.353	0.337	0.331	0.349	0.322	0.318
RSCAW						
count.wise	0.091	0.077	0.069	0.070	0.075	0.080
sect. wise	0.100	0.083	0.069	0.071	0.075	0.081
RSCAK						
count.wise	0.306	0.269	0.242	0.223	0.198	0.186
sect. wise	0.321	0.279	0.250	0.228	0.204	0.190
RSCAA						
count.wise	0.195	0.175	0.157	0.140	0.128	0.136
sect. wise	0.196	0.175	0.151	0.130	0.119	0.129
RSCAU						
count.wise	0.181	0.175	0.155	0.127	0.109	0.124
sect. wise	0.182	0.174	0.144	0.114	0.097	0.112
RSCAR						
count.wise	0.385	0.381	0.370	0.366	0.349	0.362
sect. wise	0.368	0.363	0.354	0.355	0.343	0.353

Note: 'Mean' refers to the un-weighted mean of the country-wise standard deviations across sectors and of the sector-wise standard deviations across countries.

Table 3. *Autoregressive coefficients of the revealed symmetric comparative performance of value added, exports, wage costs, capital intensity, tfp, ulc and R&D expenditure on total sample of 5-yearly annual panel data (1970-1995, 14 countries, 22 sectors)*

Variable	μ	λ	R	μ/R
	(i)	(ii)	(iii)	(iv)
RSCAV	0.944 (109.02)*°	0.013	0.943	1.001
RSCAE	0.916 (103.08)*°	0.022	0.937	0.978
RSCAW	0.709 (49.62)*°	0.052	0.789	0.898
RSCAK	0.861 (133.42)*°	0.035	0.960	0.897
RSCAA	0.801 (69.30)*°	0.045	0.874	0.916
RSCAU	0.761 (56.67)*°	0.053	0.827	0.920
RSCAR	0.890 (77.79)*°	0.023	0.890	1.000

Notes: The method of estimation is ordinary least squares. The number of observations is each time 1490. The intercepts are not presented but were each time found statistically non-significant. 'R' stands for the Pearson coefficient of correlation. 'μ' stands for the autoregressive coefficient and 'λ' for the corresponding average yearly convergence speed of the underlying *RCA* index. It is obtained as $\lambda = 1 - \mu^{0.2}$ from comparable estimates of μ on the log transforms of the *RCA* data. The proportion μ/R provides an estimate of the average proportion σ_t / σ_{t-1} during the period of estimation, where σ_t stands for the standard deviation of our measure of revealed symmetric comparative advantage at time *t*.

The t-test on μ is one-tailed and its statistic is presented between parentheses below.

* Denotes statistical significance of the t-statistic at the 5% level.

° Denotes rejection at the 5% level by the t-test on the hypothesis μ=1.

Table 4. *Pearson correlation coefficients between the revealed symmetric comparative advantage of value added and exports and the revealed symmetric comparative performance of wage costs, capital intensity, tfp, ulc and R&D expenditure, estimated on annual sector-country panel data (1972-1994, 14 countries, 22 sectors)*

	RSCAW	*RSCAK*	*RSCAA*	*RSCAU*	*RSCAR*
RSCAV	0.169	0.116	0.184	-0.125	0.515
RSCAE	0.126	0.177	0.009	-0.025	0.392

Note: The number of observations is each time 6854.

Table 5. *Explaining manufacturing value added and export specialisation: equations estimated on annual sector-country panel data (1972-1994, 14 countries, 22 sectors)*

	Value added				Exports			
Variable	(i)	(ii)	(iii)	(iv)	(i)	(ii)	(iii)	(iv)
intercept	-0.065	-0.041			-0.112	-0.099		
	(14.06)*	(8.73)*			(16.85)*	(14.57)*		
RSCAU	-0.189		-0.224		-0.022		-0.006	
	(6.15)*		(8.04)*		(0.50)		(0.14)	
RSCAW		0.199		0.243		0.314		0.362
		(3.37)*		(4.65)*		(3.70)*		(3.68)*
RSCAK		0.060		0.074		0.150		0.124
		(3.09)*		(4.01)*		(5.34)*		(4.50)*
RSCAA		0.261		0.279		-0.028		-0.005
		(8.36)*		(9.89)*		(0.63)		(0.11)
RSCAR	0.365	0.354	0.344	0.332	0.368	0.350	0.420	0.390
	(31.04)*	(30.21)*	(29.79)*	(29.12)*	(21.87)*	(20.74)*	(24.80)*	(23.54)*
Nb. obs.	6854	6854	6854	6854	6854	6854	6854	6854
Aj. R^2	0.285	0.313	0.442	0.467	0.162	0.182	0.308	0.324
St. er.	0.224	0.220	0.199	0.194	0.320	0.316	0.290	0.287
Ser. cor.	0.055	0.049	0.069	0.062	0.044	0.045	0.054	0.055

Notes: The estimation is by dynamic ordinary least squares (DOLS). The dynamic terms in the DOLS equations are not presented. The absolute value of the test statistics of the t-test on the parameter estimates are presented between brackets underneath. The standard errors underlying the t-tests are corrected for serial correlation. This correction was performed by taking a moving average of the error autocovariances using the Bartlett kernel. The number of terms in the moving average was determined by Andrews' (1991) optimal bandwith value and was chosen to be 2.

Equations (iii) and (iv) are equations (i) and (ii) estimated with country and sector specific intercepts. These intercepts are not presented.

The serial correlation test is Bhargava, Franzini and Narendranathan's (1982) Durbin Watson test for panel data. It is applied on the uncorrected residuals of the equation.

* Denotes statistical significance at the 5% level.

Table 6. *Explaining manufacturing value added and export specialisation: G7 versus Non G7 countries (1972-1994, 14 countries, 22 sectors)*

	Value added			Exports		
Variable	ALL	G7	Non G7	ALL	G7	Non G7
	(i)	(ii)	(iii)	(iv)	(v)	(vi)
intercept	-0.090	-0.004	-0.090	-0.142	-0.067	-0.142
	(13.96)*	(0.68)	(11.94)*	(15.09)*	(7.34)*	(14.32)*
dumG7	0.086			0.075		
	(9.31)*			(5.51)*		
RSCAW	0.356	0.180	0.356	0.464	0.305	0.464
	(3.76)*	(3.13)*	(3.21)*	(3.35)*	(3.09)*	(3.18)*
dumG7.RSCAW	-0.176			-0.159		
	(1.48)			(0.91)		
RSCAK	0.025	0.063	0.025	0.173	0.094	0.173
	(0.97)	(2.71)*	(0.83)	(4.64)*	(2.35)*	(4.40)*
dumG7.RSCAK	0.038			-0.079		
	(0.98)			(1.40)		
RSCAA	0.127	0.336	0.127	-0.036	-0.055	-0.036
	(2.82)*	(10.19)*	(2.42)*	(0.55)	(0.97)	(0.52)
dumG7. RSCAA	0.209			-0.019		
	(3.44)*			(0.22)		
RSCAR	0.435	0.251	0.435	0.425	0.238	0.425
	(30.26)*	(16.53)*	(25.89)*	(20.28)*	(9.11)*	(19.24)*
dumG7.RSCAR	-0.184			-0.187		
	(7.72)*			(5.39)*		
Number observations	6854	3450	3404	6854	3450	3404
Adjusted R^2	0.358	0.257	0.387	0.213	0.085	0.285
Standard error	0.212	0.170	0.248	0.310	0.291	0.327
Serial correlation	0.054	0.059	0.052	0.047	0.039	0.054

Notes: The equations correspond to equation (ii) in Table 5 and the estimation is by dynamic ordinary least squares. 'ALL' refers to the total sample, and 'G7' and 'Non G7' for the samples consisting of the G7 and non G7 countries. '*dumG7'* stands for a dummy variable that takes value 1 for the G7 countries and 0 for the non G7 countries. The absolute value of the test statistics of the t-test on the parameter estimates are presented between brackets underneath.
The serial correlation test is Bhargava, Franzini and Narendranathan's (1982) Durbin Watson test for panel data. It is applied on the uncorrected residuals of the equation.
* Denotes statistical significance at the 5% level.

Table 7. *Explaining manufacturing value added and export specialisation: research intensive versus non research intensive sectors (1972-1994, 14 countries, 22 sectors)*

	Value added			Exports		
Variable	ALL	RI	Non RI	ALL	RI	Non RI
	(i)	(ii)	(iii)	(iv)	(v)	(vi)
intercept	-0.002	-0.090	-0.002	-0.046	-0.171	-0.046
	(0.35)	(11.41)*	(0.39)	(5.21)*	(17.14)*	(4.99)*
dumRI	-0.088			-0.125		
	(9.42)*			(9.12)*		
RSCAW	-0.165	0.529	-0.165	0.142	0.524	0.142
	(2.10)*	(5.82)*	(2.31)*	(1.23)	(4.56)*	(1.18)
dumRI.RSCAW	0.694			0.382		
	(6.09)*			(2.28)*		
RSCAK	0.164	-0.082	0.164	0.303	-0.036	0.303
	(6.14)*	(2.82)*	(6.74)*	(7.75)*	(0.96)	(7.43)*
dumRI.RSCAK	-0.246			-0.339		
	(6.54)*			(6.13)*		
RSCAA	0.548	-0.068	0.548	0.078	-0.206	0.078
	(13.21)*	(1.39)	(14.50)*	(1.28)	(3.36)*	(1.23)
dumRI. RSCAA	-0.616			-0.284		
	(10.16)*			(3.19)*		
RSCAR	0.278	0.429	0.278	0.292	0.375	0.292
	(19.46)*	(21.14)*	(21.35)*	(13.90)*	(14.62)*	(13.32)*
dumRI.RSCAR	0.151			0.083		
	(6.44)*			(2.41)*		
Number observations	6854	3082	3772	6854	3082	3772
Adjusted R^2	0.370	0.308	0.374	0.217	0.182	0.180
Standard error	0.210	0.231	0.192	0.309	0.292	0.322
Serial correlation	0.054	0.036	0.074	0.048	0.048	0.047

Notes: The equations correspond to equation (ii) in Table 5 and the estimation is by dynamic ordinary least squares. 'ALL' refers to the total sample, and 'RI' and 'Non RI' for the samples consisting of the research intensive and non research intensive sectors, as indicated in the Appendix. '*dumRI*' stands for a dummy variable that takes value 1 for the research intensive sectors and 0 for the non research intensive sectors. The absolute value of the test statistics of the t-test on the parameter estimates are presented between brackets underneath.

The serial correlation test is Bhargava, Franzini and Narendranathan's (1982) Durbin Watson test for panel data. It is applied on the uncorrected residuals of the equation.

* Denotes statistical significance at the 5% level.